METHOD TO APPROXIMATE SECTION PROPERTIES OF MECHANICAL ELEMENTS THROUGH DATA OBTAINED FROM DIGITAL IMAGES

BACKGROUND

Evaluating section properties such as moment of inertia is the basic first step in analyzing the strength and deformation of mechanical elements. The process of calculating these properties by hand can quickly become extremely complex, error-prone, and time-consuming with even small increases in the number of geometric irregularities in the section profile. CAD programs use complex mathematical models of the cross-section to achieve this and as a result incur high costs in software, hardware, and user skill level. These models are laborious to modify if small changes are desired. The object of the present invention is to provide an accurate method of deriving the section properties for simple as well as highly irregular cross-sections quickly in the office or in the field without hand calculation and without complex mathematical models and therefore without the expense of high-end hardware and software.

SUMMARY

The proposed method for approximating section properties of a mechanical element manipulates data gathered directly from digital images that represent the cross-section in question. This makes the process quicker, eliminates human error, and is cost-efficient due to the stand-alone nature of the otherwise simple code required and the simple interface that requires no specialized programming, software, or engineering skills. A digital image of the cross-section is created by scanning the cross section, or scanning a sketch of the cross section, or creating the digital image with photo-editing software, or creating the image from sensor data, or obtaining the graphics file by other means. The digital image is then saved as a two-color image with one color signifying empty space. A computer program designed to accommodate the preferred graphics file type queries the image pixel-by-pixel for the color property. When preferred-color pixels are detected the pixel position data is recorded as x and y coordinates. In one preferred embodiment a 2 x *n*

array is created where n is the number of preferred-color pixels. However the data is arranged, standard engineering formulas adapted for use with the arrangement are then used to develop the section properties.

EXAMPLE

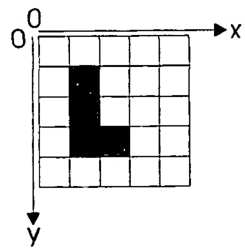

Figure 1 An example digital image with each square representing a single pixel, white signifying empty space and black as the preferred color

X	Y
2	2
2	3
2	4
3	4

Figure 2 The corresponding array

The standard engineering formulations adapted to the array:

A = area of each pixel, in^2

$$= \left(\frac{1}{xres}\right)\left(\frac{1}{yres}\right) \tag{1}$$

where xres and yres are the resolution of the digital image in pixels/inch

I_{cx}^{i} = the centroidal moment of inertia for each pixel about its x axis, in^4

$$= \frac{\left(\frac{1}{xres}\right)\left(\frac{1}{yres}\right)^3}{12} \tag{2}$$

y_{ci} = the vertical distance between the centroid of each pixel and the upper edge of the image, in

$$= \frac{1}{yres}(y_i - .5) \qquad (3)$$

y_c = the vertical distance between the upper edge of the image and the centroid for the aggregate shape, in

$$= \frac{\sum_{i=1}^{n} A_i y_{ci}}{\sum_{i=1}^{n} A_i} \qquad (4)$$

$$= \frac{A\sum_{i=1}^{n} y_{ci}}{nA} \qquad (5)$$

$$= \frac{1}{n}\sum_{i=1}^{n} y_{ci} \qquad (6)$$

$$= \frac{1}{n \cdot yres}\sum_{i=1}^{n}(y_i - .5) \qquad (7)$$

d_{yi} = the vertical distance between the centroid of each pixel and the centroid of the aggregate shape, in

$$= y_{ci} - y_c \qquad (8)$$

$I_{cx'}$ = the centroidal moment of inertia of the aggregate shape about its x axis, in^4

$$= \sum_{i=1}^{n}\left(I_{cx}{}'^{\,i} + A_i d_{y_i}{}^2\right) \qquad (9)$$

$$= \sum_{i=1}^{n} I_{cx}{}'^{\,i} + A\sum_{i=1}^{n} d_{y_i}{}^2 \qquad (10)$$

$$= nI_{cx}{}'^{\,i} + \frac{A}{yres^2}\sum_{i=1}^{n}\left(y_i - .5 - \frac{1}{n}\sum_{i=1}^{n}(y_i - .5)\right)^2 \qquad (11)$$